LINCOLN ELECTRIC SYSTEM
www.les.com

Undergrounding Electric Service

Lincoln Electric System (LES) maintains an electric transmission and distribution system that consists of both overhead and underground lines. LES currently maintains 1,728 miles of distribution within its service area. Of this amount, 725 miles are overhead and 1,003 miles are underground. LES also has 230 miles of transmission lines in the area.

Periodically there are discussions about more aggressively moving to convert existing overhead lines to underground. The purpose of this document is to provide a thorough understanding of the issues, advantages, disadvantages, and costs related to undergrounding as a basis for a policy discussion of the issue.

Definitions

To be sure there is a common understanding of terms used in this paper, following are definitions for some of the key terms.

- **Transmission lines** – These are the larger, very high voltage lines around Lincoln. They operate at voltages of 115,000 volts to 345,000 volts. They may be on various types of wood or steel structures. They are characterized by insulator strings (that hold the wire to the structure) which are in excess of three feet long.

- **Distribution lines** – These are lines that operate at 12,000 volts or 35,000 volts. Distribution lines can be above or below ground.

- **Service line** – The low voltage 120 volt – 480 volt lines that go from a neighborhood transformer to a customer service entrance.

- **Customer service entrance** – The point at which LES' service lines attach to the customer equipment, typically a meter socket for residential customers. The customer owns the service entrance which is the customer's responsibility to maintain. This piece of equipment must be changed when an overhead service is converted to underground.

Attachment A provides a photographic illustration of some of these lines.

Current Practice

LES has been placing new electric distribution lines underground to various degrees since the early 1960s. In new residential areas, distribution facilities are placed underground. Historically, LES did not charge developers to extend overhead lines to serve new customers. Recognizing that underground facilities are more expensive to install, LES charges developers in new areas the difference between the overhead and underground costs.

In 1972 about 8% of LES customers were served by underground facilities and today that number is about 70%. Most of the increase is due to new construction being served by underground facilities with a smaller amount due to conversion of existing customers from overhead to underground. (See chart in Attachment B.)

The Lincoln-Lancaster County Comprehensive Plan includes a provision to "within the City of Lincoln, wherever feasible and affordable, implement a phased program to relocate overhead utility lines underground."

LES' approach focuses on the economics of various undergrounding situations in order to keep electric rates low. (The current LES policy on underground facilities is in Attachment C.) The higher the voltage, the more expensive it is to place underground. Economic considerations rule out placing the high voltage transmission lines underground, so the rest of this paper will focus on placing distribution facilities underground. In the distribution area, the economics sometimes favor undergrounding if there is a triggering event such as the following:

- **Arterial Street Widening** – The line is generally placed underground if the utility poles would have to be moved. These projects are closely coordinated with City Public Works and utilities.

- **Private Requests** – Customers requesting conversion of overhead facilities to underground or relocation of facilities are charged the non-betterment cost of burying the facilities, generally meaning the non-depreciated value of the facilities.

- **Rewire Services** – Where feasible, LES will convert a service line to underground at no charge if the customer provides a clear path or conduit and a service entrance is designed to accept underground service.

In recent years, LES has been investing between $1 million and $1.5 million annually to convert 2 to 3 miles of existing overhead distribution lines to underground. In addition, about $400,000 per year is spent converting about 500 service lines to underground. More than $4 million per year is needed to extend underground facilities to new residential and commercial customers.

Rural arterial roads – New, rebuilt, and relocated lines along rural arterial roads will be placed overhead, primarily because overhead lines can be moved rather easily, sometimes reusing the existing materials. Underground installation will be considered if the area is developed, is at final grade, and the facilities can be buried in an easement area 60 to 75 feet from the street center line. This prevents LES from having to relocate underground facilities repeatedly at a cost that can be 2 to 5 times higher than relocating overhead lines.

Reliability Issues

The long term reliability of electric service is not significantly improved with underground facilities. What we find is that the types of outages on overhead and underground facilities are very different.

Outages of overhead facilities often occur during storms and are related to lightning, squirrels, wind and ice. Underground facilities generally escape direct damage due to storms, but they are prone to other failures. The most common underground failures are due to "dig-ins," splice failures and cable deterioration. Dig-ins, as the name implies, are due to contractors or building owners striking an underground line while constructing another building or a fence. As they age, splices in underground cables fail, and sometimes the cable itself fails. These outages are more difficult to locate and often more time-consuming and costly to repair because they require digging up the cable, making the repair, and re-burying the cable. These outages occur on a more random basis than the storm related outages of overhead lines. The life of an underground cable is at least 10 years shorter than an overhead line. An increasing number of underground cables are passing 30 years in service and the number of underground outages has been increasing in the past few years.

Aesthetics

The clear benefit of underground lines is aesthetics due to the elimination of poles, wires and the associated tree trimming.

Challenges of placing facilities underground

- Cost – The cost to install and rebuild underground lines is typically 2 to 5 times higher than overhead lines.

- Outage response – The process to find, dig up and repair an outage on underground facilities is more time-consuming than overhead lines.

- Existing obstacles – Undergrounding in many areas may require excavating near or around a number of obstacles. Typical obstacles that could be encountered include:

Concrete alleys	Gardens, flowers	Swimming pools
Parking lots	Railroad rights-of-way	Fences
Streets and sidewalks	Driveways	Buildings
Tree roots and shrubs	Retaining walls	Other UG utilities

- Equipment boxes – In some cases, pole mounted electrical equipment will have to be relocated to ground level boxes when overhead lines are converted to underground.

Types and Costs of Conversion

The cost of burying overhead lines is significant and can vary depending on the type of line and its location. The following table provides a general overview of the cost of burying LES overhead distribution facilities within the urban area.

Type of Line	No. of Miles	Cost per Mile	Cost Estimate
• 12kV Without load-serving transformers along streets	132	$450,000	$60 million
• 12kV With load-serving transformers along streets	90	$800,000	$72 million
• 12kV With load-serving transformers along alleys	221	$800,000	$177 million
• 35kV distribution	35	$500,000	$18 million
• Service lines for 40,000 customers	-------		$50 million
Total:	478		$377 million

There would be additional direct costs for customers along lines with load serving transformers. There are approximately 40,000 customers served from overhead facilities who would also be responsible for retaining an electrician to change their individual service entrance to be able to accommodate underground lines from LES. For residential customers, this cost would be about $250 - $500 per customer.

If overhead lines along the street also support street lights, then a new street lighting system would also have to be installed at a cost of approximately $150,000 - $180,000 per mile.

Finally, it should also be noted that these estimates only reflect costs to LES and its customers. Not taken into account are any costs associated with converting any overhead telephone or cable television facilities.

In addition, there are about 248 miles of line outside of the city limits that would generally not be practical to convert until urbanization occurs.

Examples

See Attachment D for examples that include photos showing situations that are encountered when converting overhead facilities to underground.

Policy Issues

As noted, LES currently spends about $1 million to $1.5 million per year converting overhead distribution lines to underground. The key policy issue that arises from this discussion is whether the aesthetic benefits of placing facilities underground justifies the cost of a more aggressive conversion program. This policy discussion rests with the LES Administrative Board and the Lincoln City Council which approve LES' budget and rates.

If it is determined that a more aggressive undergrounding program should be implemented, the next step is to quantify the goal and determine how the projects should be funded. The math is simple, but the numbers are large. From the table above, there could be over $300 million of LES facilities eligible for conversion. (This number excludes the costs to the city for related street light systems and the costs to customers to modify service entrances.) A 1% increase in electric rates generates about $1.6 million. With a permanent 10% rate increase it would take nearly 20 years to accomplish a complete conversion of the urban system.

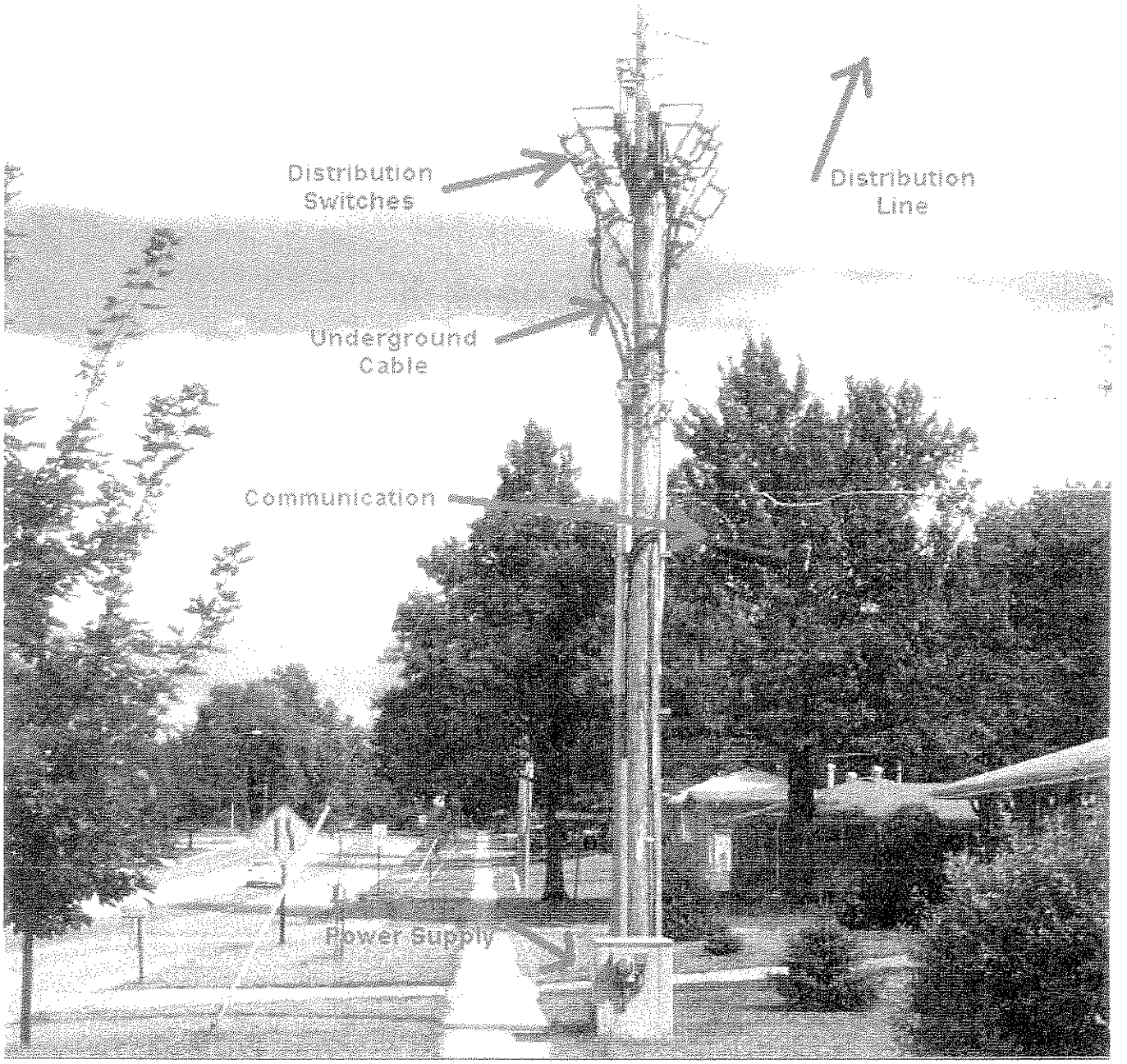
It may be appropriate to consider other funding mechanisms rather than using the same percentage increase for all customers. The benefits of the aesthetic improvements are probably not proportionate to electricity use. A flat percentage increase would place a proportionately higher burden on industrial customers while the benefits would largely occur in residential areas.

It is possible to use bonds to some extent to leverage quicker conversion, however bonds do not reduce the ultimate cost to customers, they just extend the payment period.

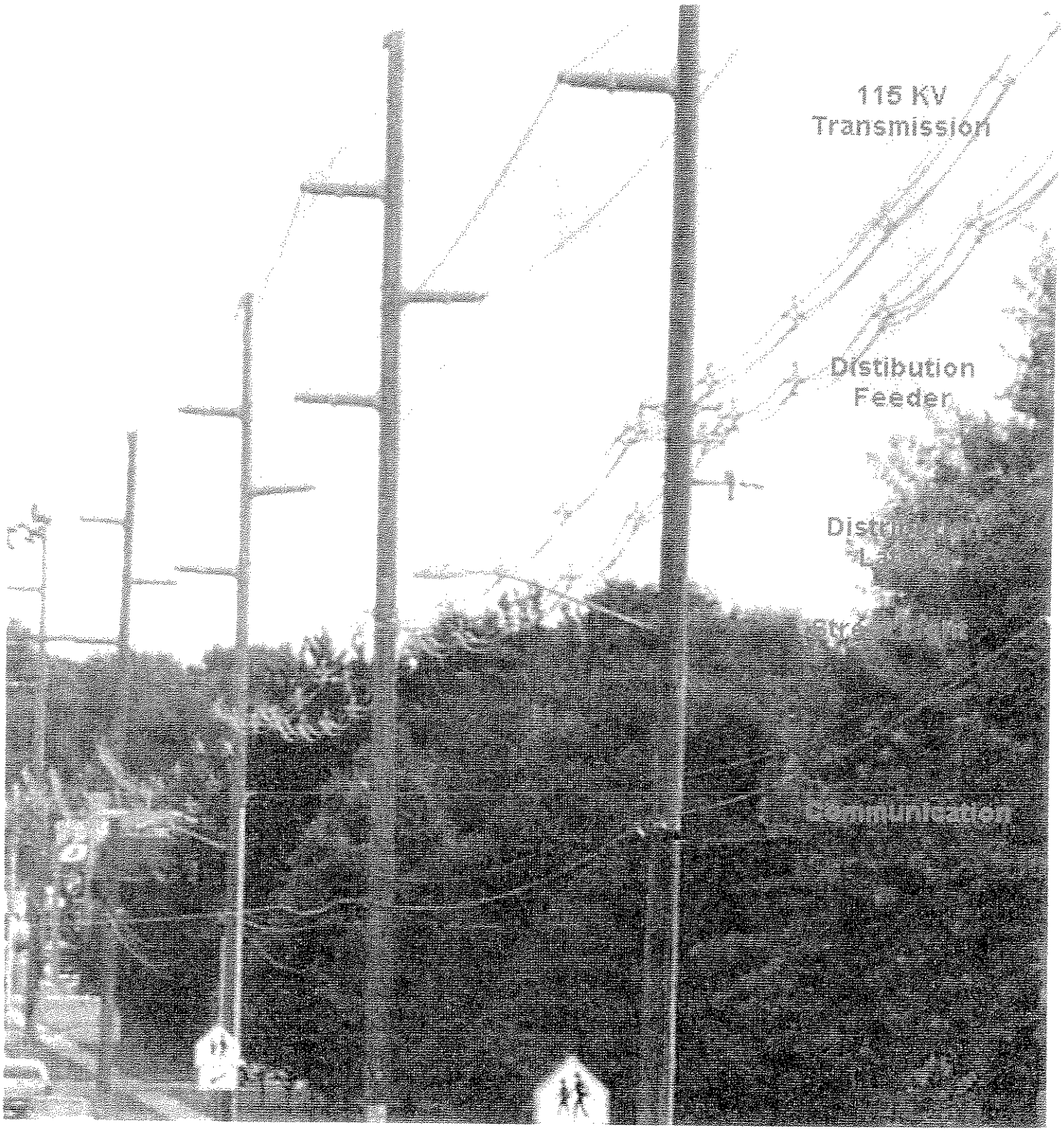
Summary

While LES is comfortable with the current conversion program, there is no clear right or wrong approach to the underground conversion issue. It is a matter of balancing the public benefits of the aesthetic improvements with the economic impact of rate increases that will be needed to expand the annual number of miles converted.

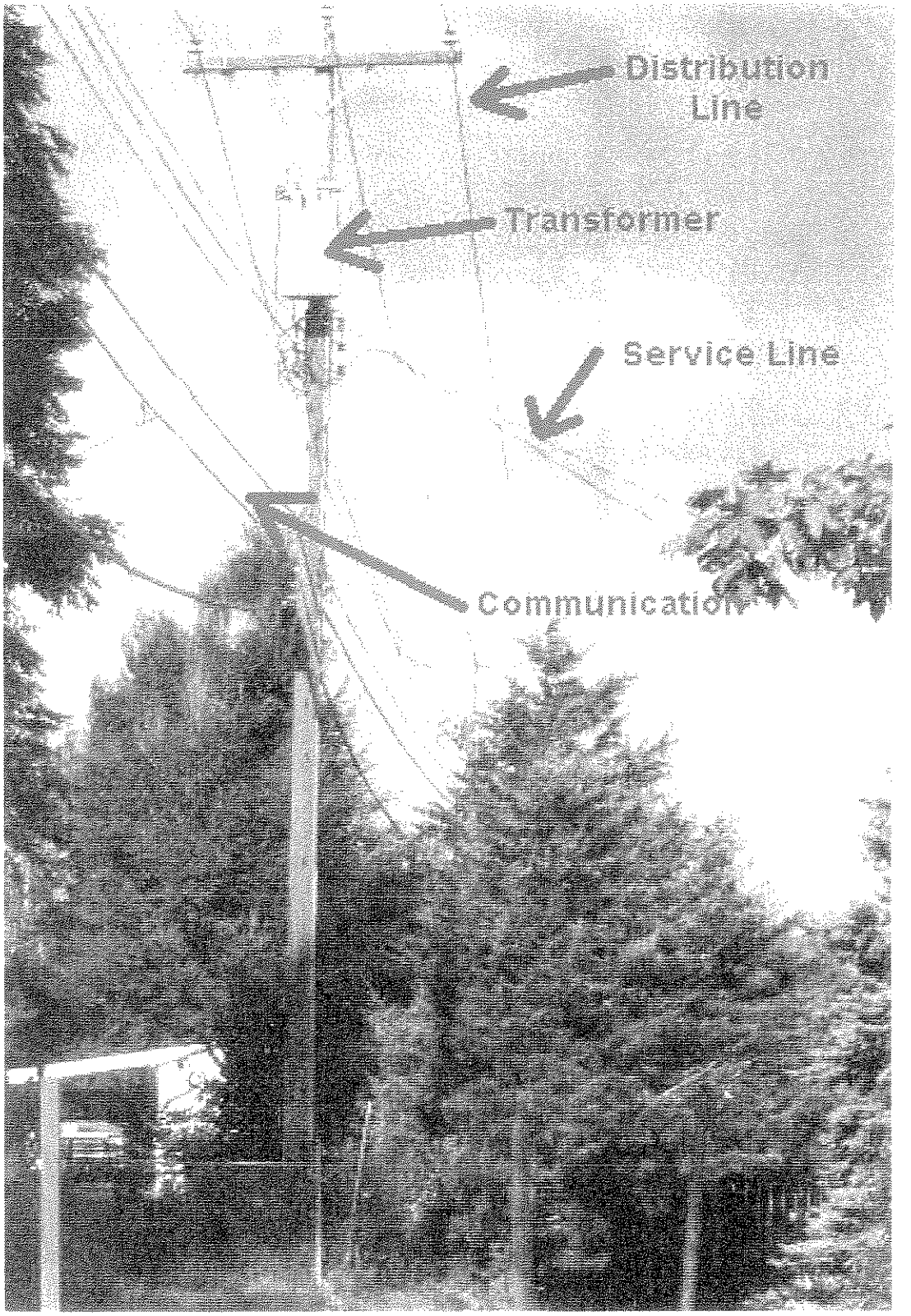
Attachment A



Identified facilities on an overhead to underground transition pole.



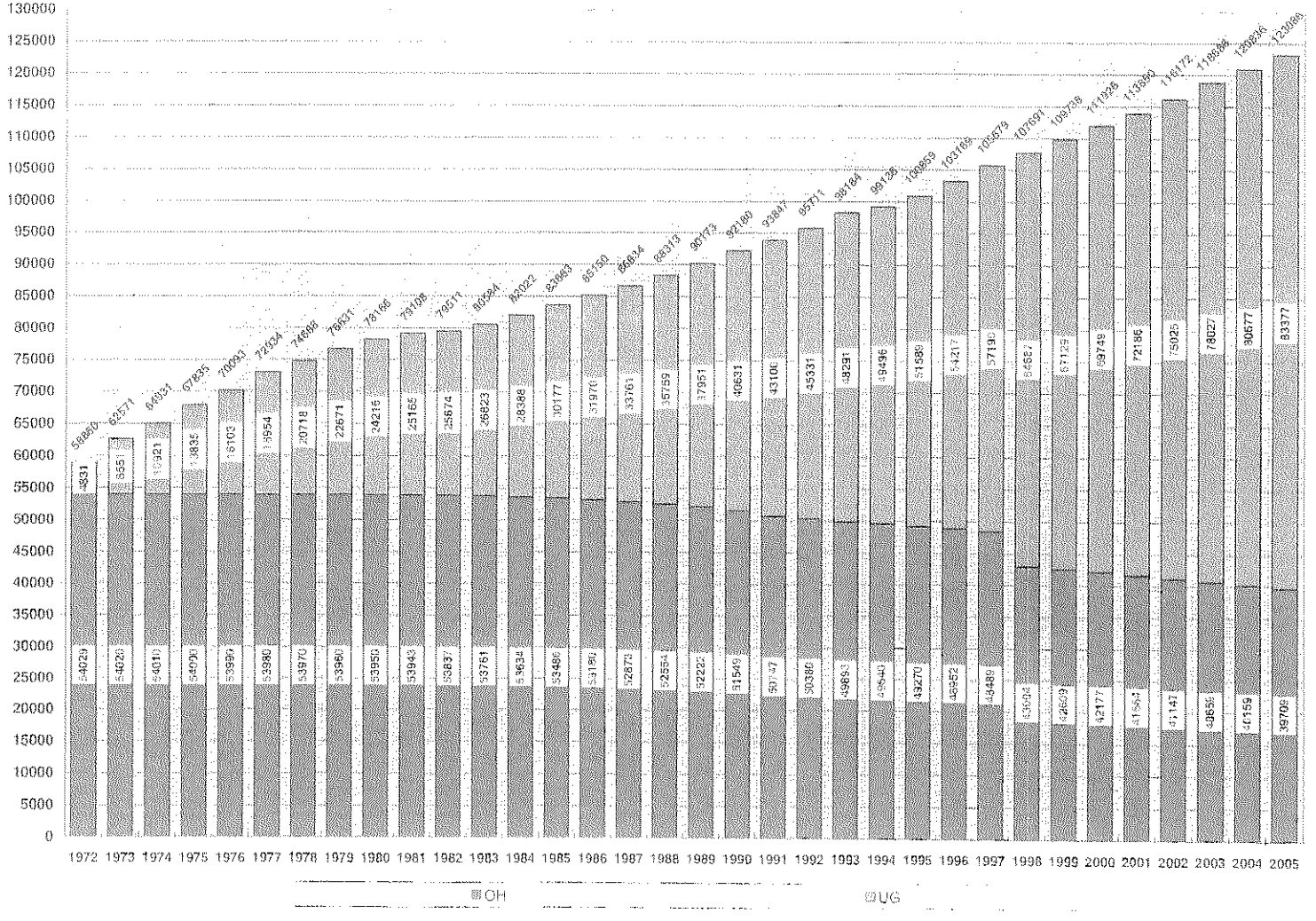
Identified overhead facilities on transmission poles



Identified overhead facilities on a transformer pole.

Attachment B

Overhead/Underground Customer Counts



Attachment C

LINCOLN ELECTRIC SYSTEM

UNDERGROUND AND RELOCATION POLICY

It shall be the policy of Lincoln Electric System (LES) to actively encourage the installation of its electric facilities underground. Major new construction of primary and secondary systems will be installed underground if determined to be feasible by the Engineering Division.

1. **Arterial Street Widenings**

   LES will install the distribution circuit underground if the existing pole line must be removed or if the poles will be less than a reasonable distance from the back of the curb after the arterial is widened. The Engineering Division will be responsible for determining a reasonable distance from the back of the curb.

2. **New Primary Distribution Systems**

   LES, when determined by the Engineering Division to be feasible, will install all new feeders underground where there is not an existing pole line. If there is an existing pole line the Engineering Division will be responsible for determining the feasibility of installing the feeder underground, using a base factor such that the cost of underground is not more than 2 times the cost of installing the feeder overhead.

3. **Underground Service in New Residential Areas (Single-Family Dwellings, Townhouses, Duplexes with a Meter Center, and Mobile Homes)**

   LES will own, install, operate, and maintain an adequate underground distribution system including the service wires to the meter socket on the outside of the house or structure.

   a. In subdivisions the customer or developer will contribute an aid-to-construction of $150.00 per lot for lots with rear lot lines 100 feet in width or less and $1.50 per rear lot foot for lots with rear lot lines greater than 100 feet in width. The aid-to-construction under this subsection shall not exceed $300.00 per lot.

   b. In mobile home parks the customer or developer will contribute an aid-to-construction of $35.00 per lot for an adequate underground distribution system and will also own, install and maintain the meter pedestal.

c. In either (a) or (b) above, 100% aid-to-construction payment (or a 20% payment of the aid-to-construction cost and an acceptable payment bond or escrow account for the 80% balance) will be required 30 calendar days before the beginning date of LES' construction. The remaining 80% will be due, if applicable, upon completion of the project, project phase, or that portion of the project or project phase completed to date and is delinquent if not paid in 10 calendar days following billing by LES.

4. Conversion of Existing Overhead Facilities to Underground and Relocation of Existing Overhead and Underground Facilities

Public and private groups or individuals requesting existing overhead facilities to be installed underground or requesting the relocation of existing overhead or underground facilities will be required to pay the aid-to-construction cost of doing this work. The Engineering Division will be responsible for determining the aid-to-construction cost and feasibility of such conversions or relocations.

5. Underground Service in Existing Residential Areas for New Construction (Single-Family Dwellings, Townhouses, an Duplexes with a Meter Center)

LES will own, install, operate and maintain the underground service wires to the customer-owned meter socket wherever direct burial access is feasible. LES will be responsible for determining the feasibility of the installation.

6. Underground Service to Newly Constructed Multi-Family Dwellings, Condominiums, and Commercial Buildings (Excluding Duplexes with a Meter Center)

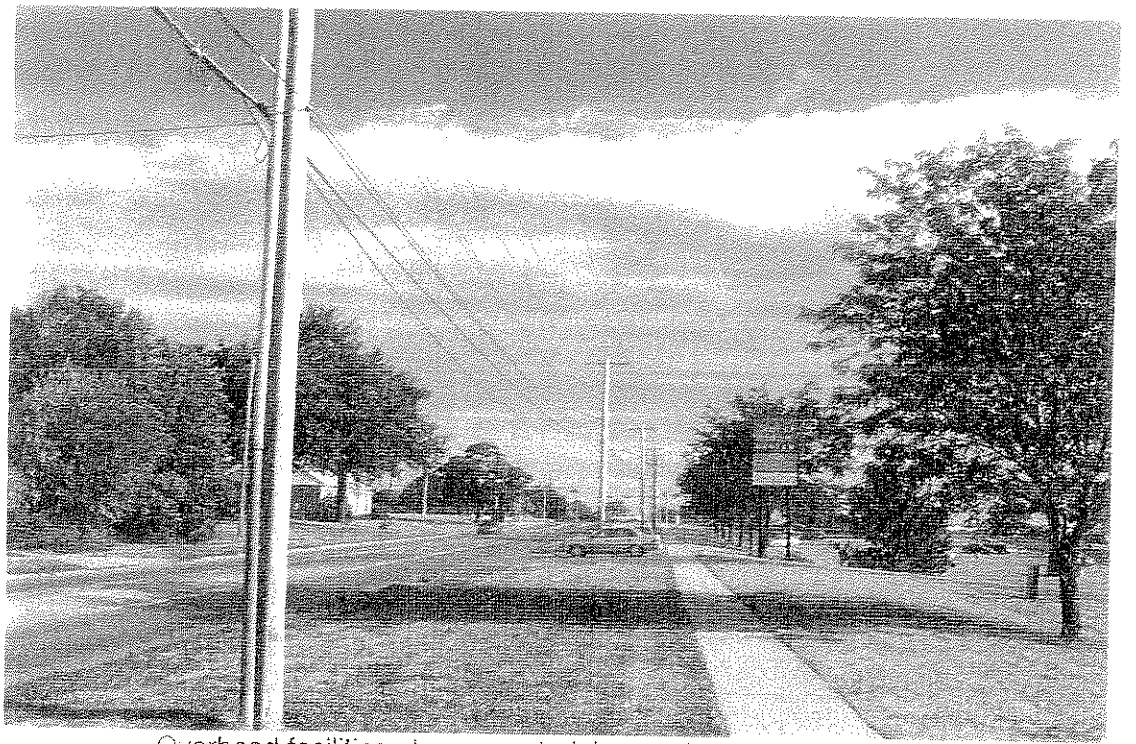
a. LES will own, install, operate and maintain the primary and secondary conductors to the point of termination of the customer's switchgear, bus duct, or metering point.

b. The customer will supply, install and maintain the secondary conduit(s), bus duct and transformer pad or vault, subject to LES' specifications and approval. Service from transformer vaults is not standard and may require an aid-to-construction. In cases where LES does not require a transformer pad or vault, the customer will supply and install the secondary conduit(s) to a point designated by and subject to LES' specifications and approval.

7. Grade Changes and Erosion

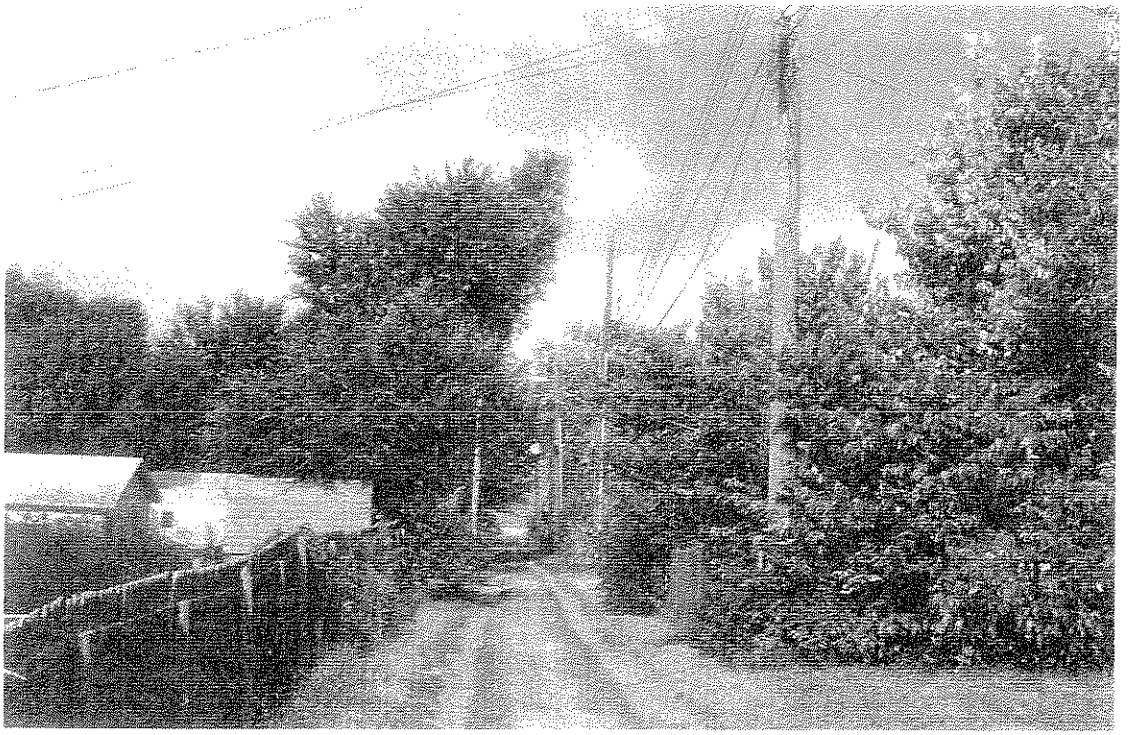
The property owner shall be liable to LES for all costs incurred in the relocation and repair of LES overhead and underground facilities necessitated by grade changes and erosion on the property.

Attachment D



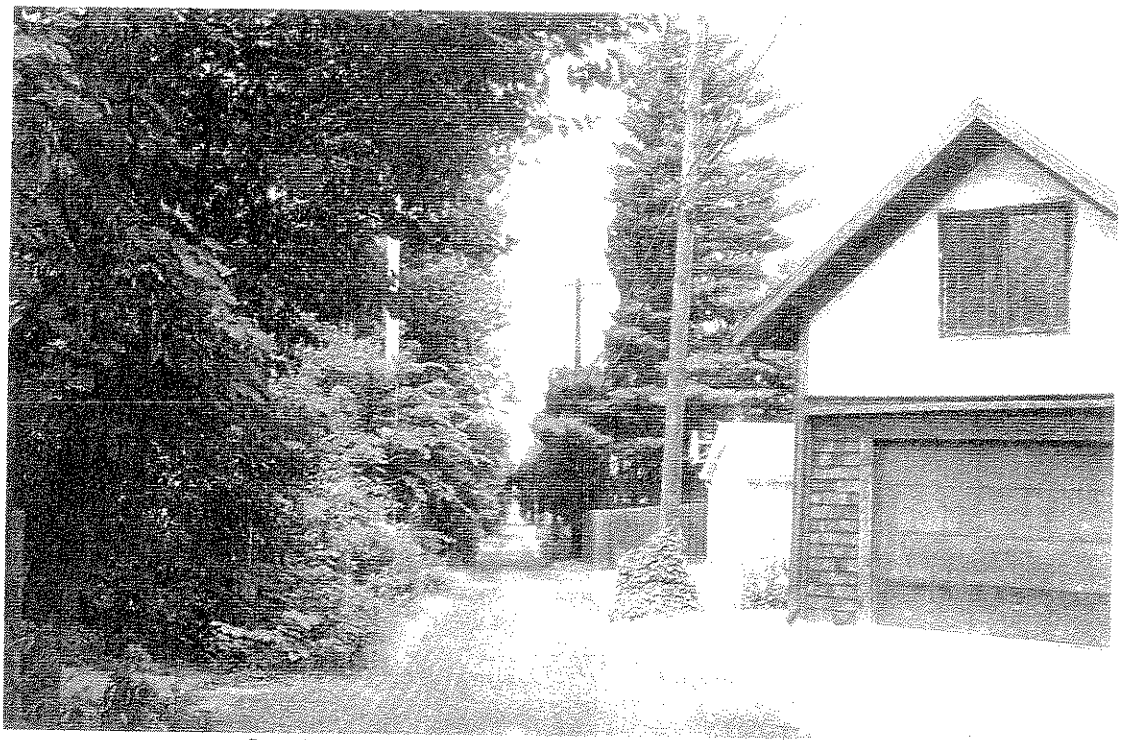
Overhead facilities along an arterial street in a commercial area.

Overhead facilities along an arterial street in a residential area.



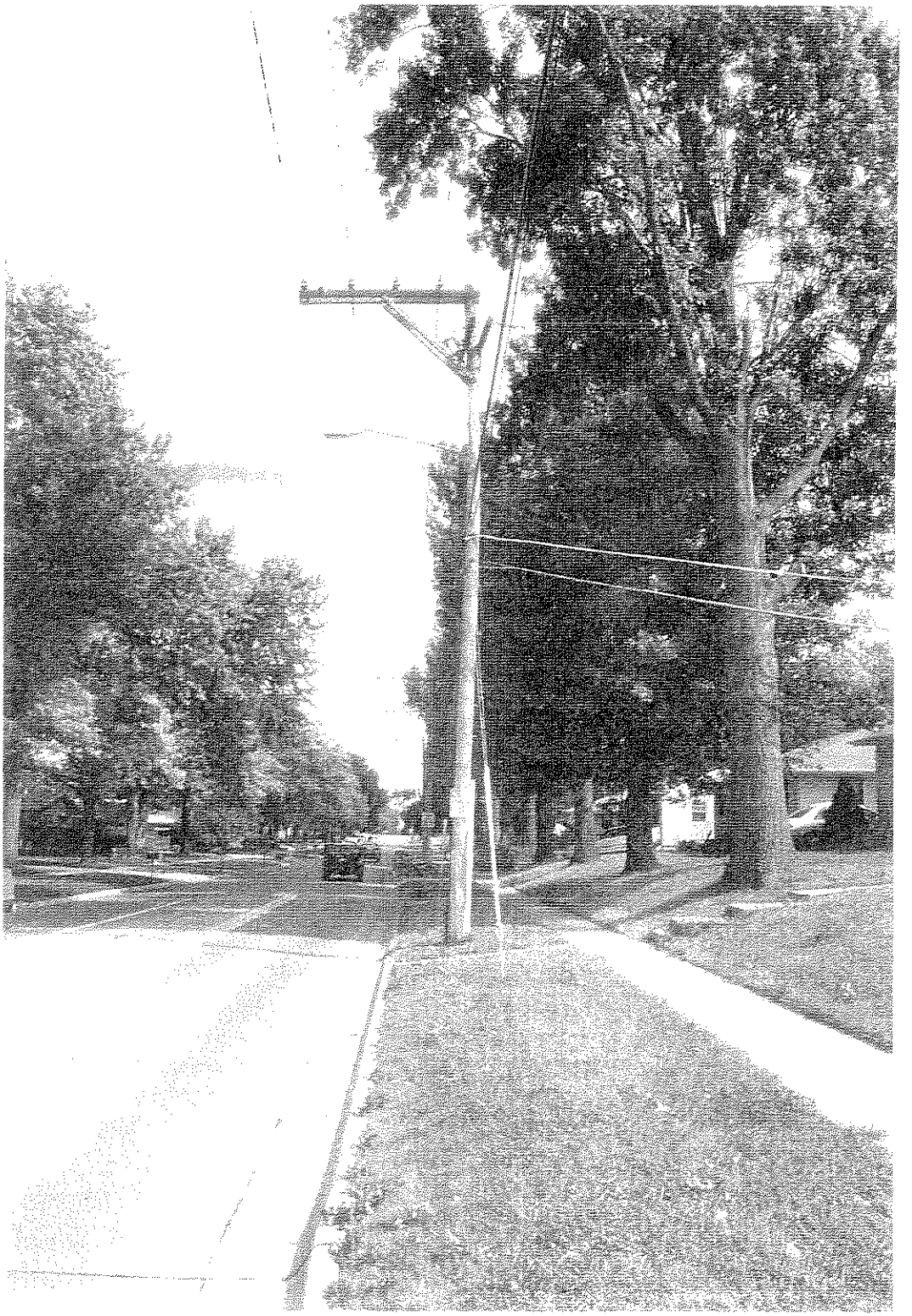
Overhead facilities along a residential alley.

Overhead facilities along residential back lot lines.



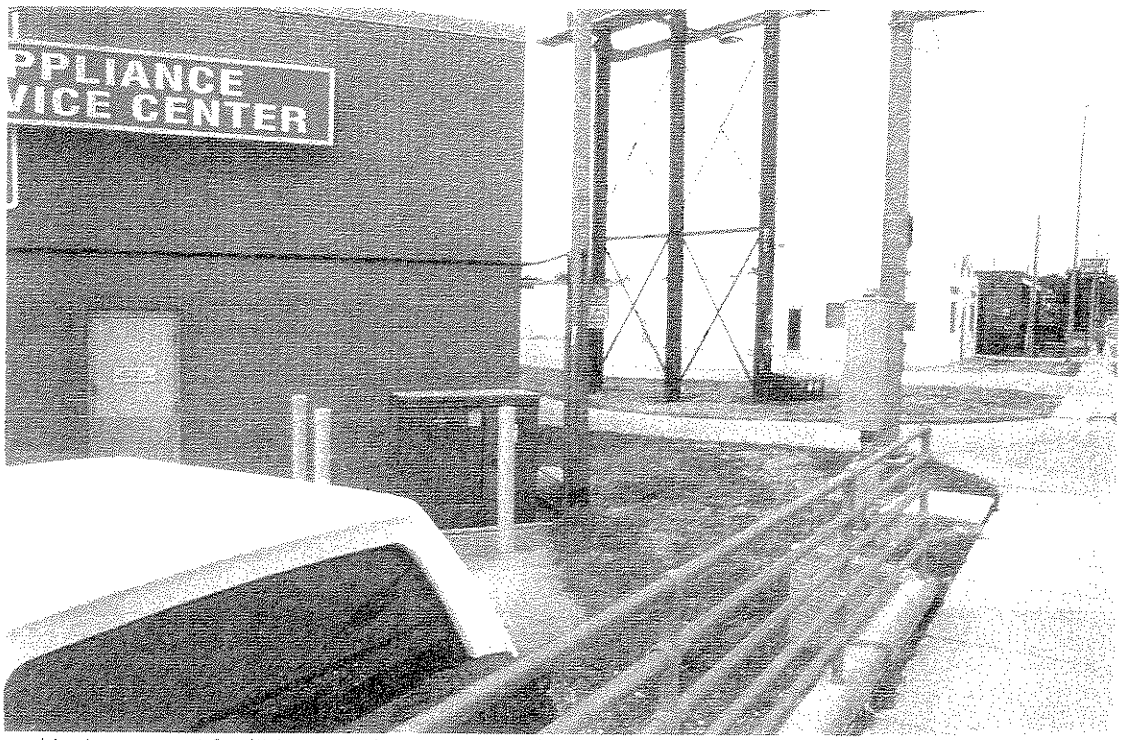
Overhead facilities along a paved residential alley.

115kV transmission line and overhead distribution facilities along an arterial street.

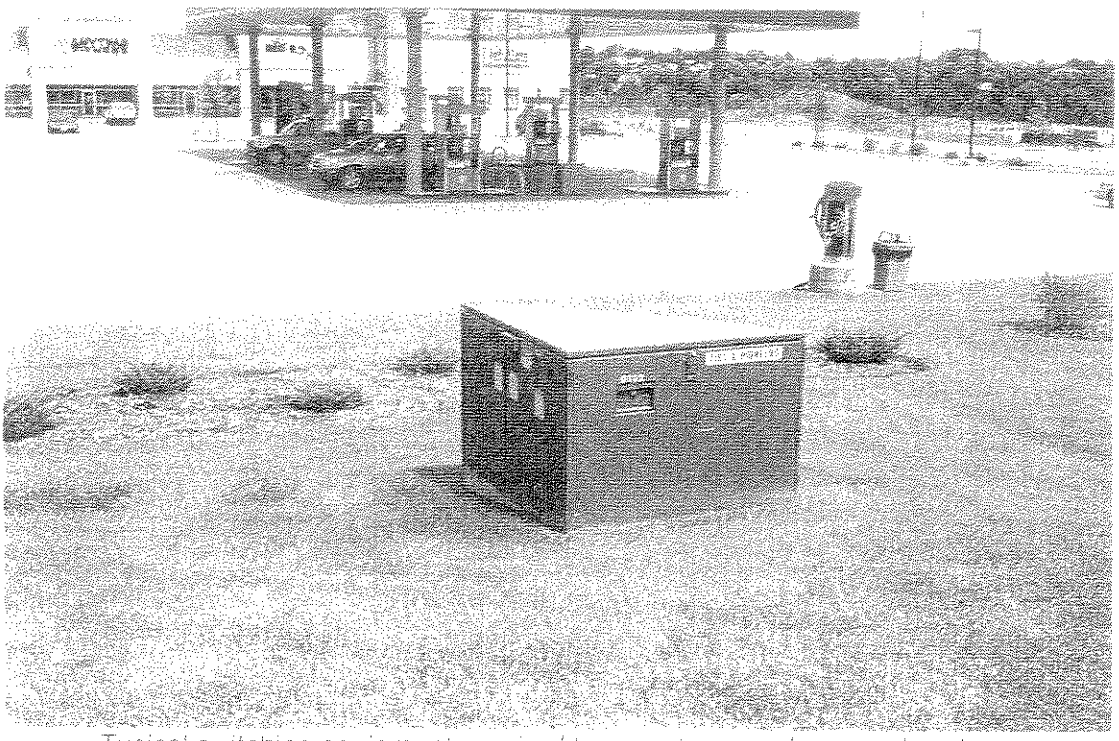


Overhead facilities along an arterial street.

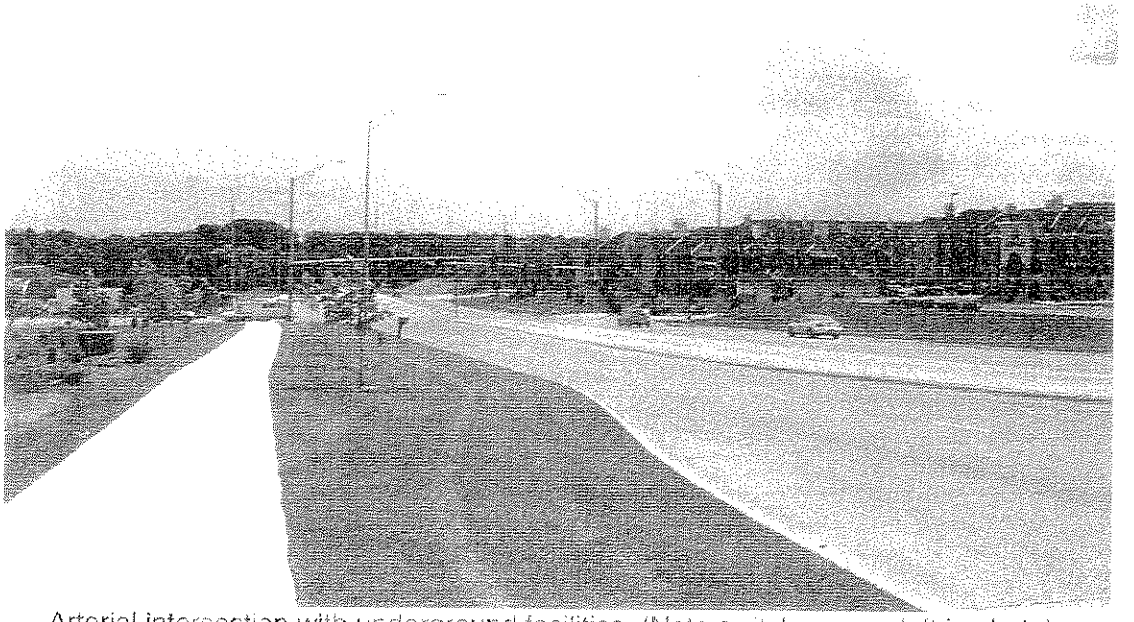
Underground facilities serving a commercial customer with an overhead service line. (Customer chose not to convert their equipment.



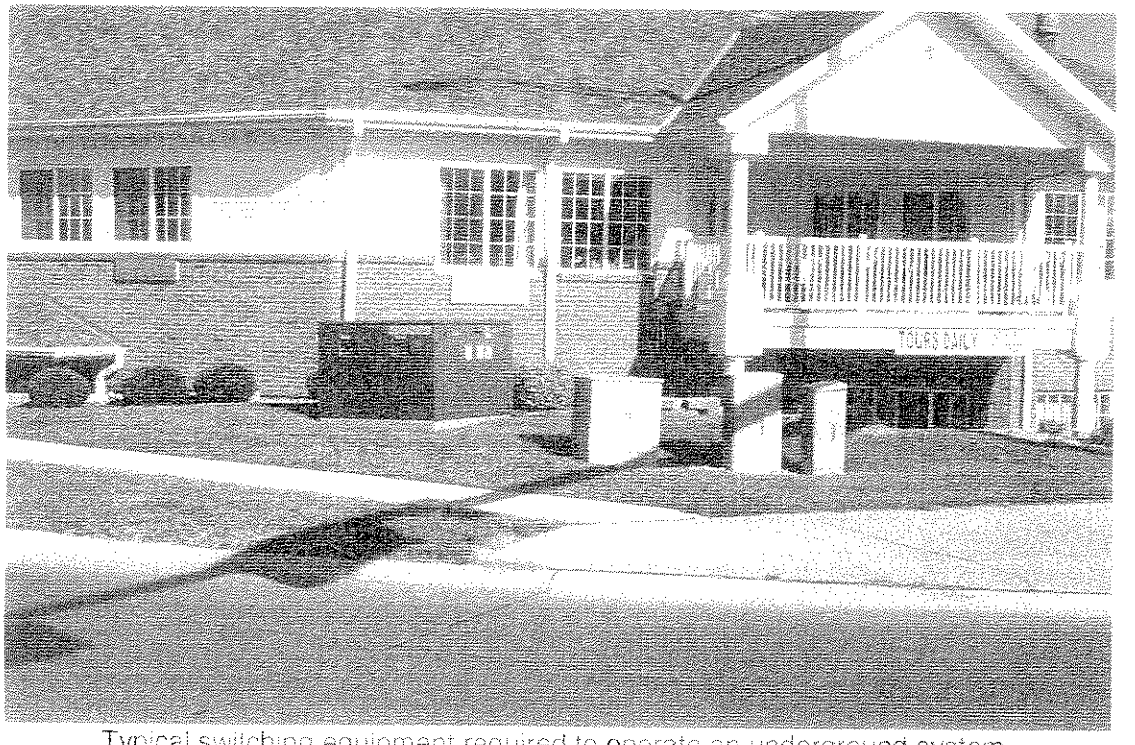
Underground facilities serving commercial customer with an overhead service line..



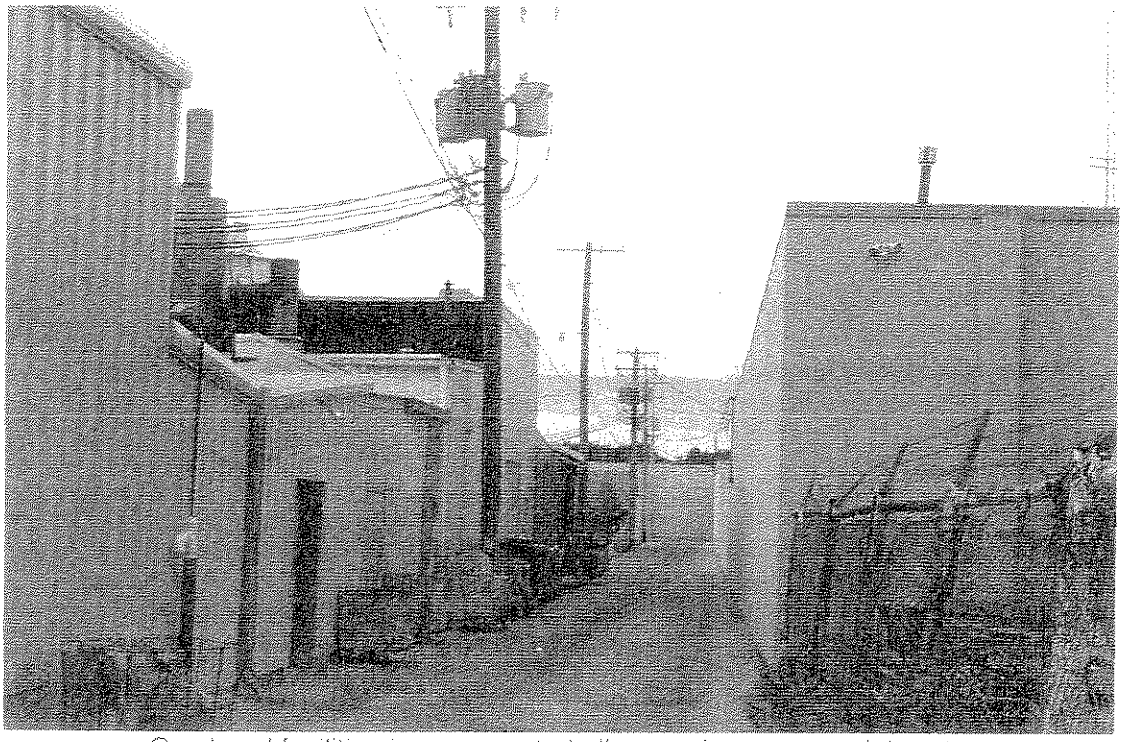
Typical switching equipment required to operate an underground system.



Arterial intersection with underground facilities, (Note switchgear on left in photo).



Typical switching equipment required to operate an underground system.
Plus traffic control and communication equipments



Overhead facilities in a congested alley serving commercial customers.

Equipment for underground distribution system.